SOUTHWEST FISHERIES SCIENCE CENTER
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Submitted by: John R. Hunter, Division Director, Fisheries Resources Division.

Title of Milestone: Analysis of Mako Shark Growth Rate.

Current Status: Work is continuing to obtain a larger sample size, particularly the vertebral sections from larger, older fish.

Background Information: How fast shortfin mako sharks grow remains unresolved. This limits mortality rate and demographic analyses that are needed for stock management. This project involves aging vertebra that were collected mainly in the central north Pacific by Japanese fishing training vessels. The specimens were supplied to the La Jolla Laboratory by the National Research Institute of Far Seas Fisheries, Japan.

Purpose of Activity: Activity involves cross and sagittal (bow tie) sectioning of vertebral centra using a jeweler's saw, obtaining x-ray radiographs, reading them for age, and developing a growth curve. The purpose is to describe growth rate and size at maturity of north Pacific shortfin mako.

Description of accomplishment and significant results: All centra radiographs were re-read (6th reading), and a von Bertalanffy growth law was fitted to 54 age-length measurements that were deemed accurately aged. Measurements at each age interval were given equal weight to prevent the more numerous data from smaller centra from biasing the fitting. The resulting growth equation, sexes combined, for cm *body length* (specimens were measured to the tail base) with age in years is:

$$l_t = 232\,[1-e^{-0.2473(t-t(o))}].$$

The following are the expected cm *fork length* with age, according to a slow-growth "1 ring/yr" hypothesis (Cailliet and Bedford, 1983, CALCOFI Rep., XXIV:57-69), this Present Study, and a fast-growth "2 rings/yr" hypothesis (Pratt and Casey 1983, Can. J. Fish. Aquat. Sci. 40:1944-1957):

Fork Length by Age

Age	1 ring/yr	Present Study	2 rings/yr
0	68.6 cm	66.8 cm	67.0 cm
1	84.4	108.5	119.9
2	99.2	141.0	161.7
3	112.9	166.4	194.8
4	125.6	186.2	221.0
6	148.5	213.8	258.4
8	168.3	230.6	282.0
10	185.5	240.9	296.9
15	219.0	252.2	314.7
4	296.3	257.1	323.5

Significance of accomplishment: These results are still preliminary, but they indicate the shortfin

mako is a fast-growing shark, but not as fast as given by the 2 rings/yr reading. The species grows somewhat faster than 30 cm/yr (1 ft/yr) during the first two years following birth. From the mako's predicted size at age, the most important length frequency modes in the drift gillnet fishery are seen to correspond to ages 1 to 3. This study also indicates that growth rings are comprised of congested circuli (denser to x-rays) formed when growth is slowed, and that there can be 1, 2, or more rings formed per year. Annual growth increments tend to each have a particular internal structure, and successive increments are smaller.

Problems: Several areas of uncertainty remain. The growth model needs to be developed from a larger sample size, with older specimens better represented. The criteria for determining annual growth increments needs to be quantified. Work is proceeding to process more centra from larger (older) specimens for age reading. These and previously processed centra will also be examined with new digital imagery software to help discern consistent criteria for determining annual increments. The age determinations must eventually by validated against increments from known time intervals, and for this, tetracycline-marked mako are being released in the shark survey carried out by SWFSC in the southern California Bight. A goal for this study is to determine the mako's size and age at maturity. For this both growth rate and the average size at maturity needs to be better established, because some size records in the literature for mature females indicate maturity as early as age 3, which is implausible.

Contact: David Au, Ph (858) 546-7071; Darlene Ramon, Ph (858) 546-7074.